Niveau(x) d'enseignement : 0 Numéro EDUQ : 9270762
Centre d'intérêt : 840

Solomon, Joan.

Science education through science technology and society / par Joan Solomon. -- Montréal : Université du Québec à Montréal, Centre interdisciplinaire de recherche sur l'apprentissage et le développement en éducation, 1992.
14 f. : ill. ; 29 cm. -- (Séminaire sur la représentation ; 67)

Bibliogr. : f. 14.

ISBN 2-921284-88-X

Vedette(s)-secondaire(s) : Université du Québec à Montréal. Centre interdisciplinaire de recherche sur l'apprentissage et le développement en éducation

Descripteur(s) : Sciences * Technologie * Société * Objectifs d'enseignement

En Grande-Bretagne, on a graduellement placé l'enseignement des sciences dans un contexte social. Ce document met d'abord en évidence quelques arguments concernant les rapports entre la science et la société. En second lieu, il fait le lien entre ces rapports et les objectifs de l'enseignement eux-mêmes. Finalement, il démontre que l'école peut non seulement bien enseigner la science mais également faire comprendre la nature de la science, les enjeux sociaux de la technologie et la participation du citoyen. L'approche ##Science Technology and Society education## constitue une éducation par le biais de la science mais aussi à l'intérieur de la science.

Type de document :

9270762

CENTRE INTERDISCIPLINAIRE DE RECHERCHE SUR
L'APPRENTISSAGE ET LE DEVELOPPEMENT EN EDUCATION

CIRADE

Université du Québec à Montréal

927-962

Science Education through Science Technology and Society

par Joan Solomon
Department of Educational Studies
Oxford University
Great Britain

Séminaire sur la Représentation
28 octobre 1991 - n° 67

CIRADE, UQAM, mars 1992

ISBN 2-921284-88-X

Abstract

In Britain we have gradually been introducing a social context into school science education. The Task is far from complete but the struggle has forced us to think rather hard about the problems. The more recent research programme for examining and enhancing the *Public Understanding of Science* has also illuminated this work. This talk will begin by outlining some of the arguments about the connections between science and society. The second part will relate these to the major aims of education itself.

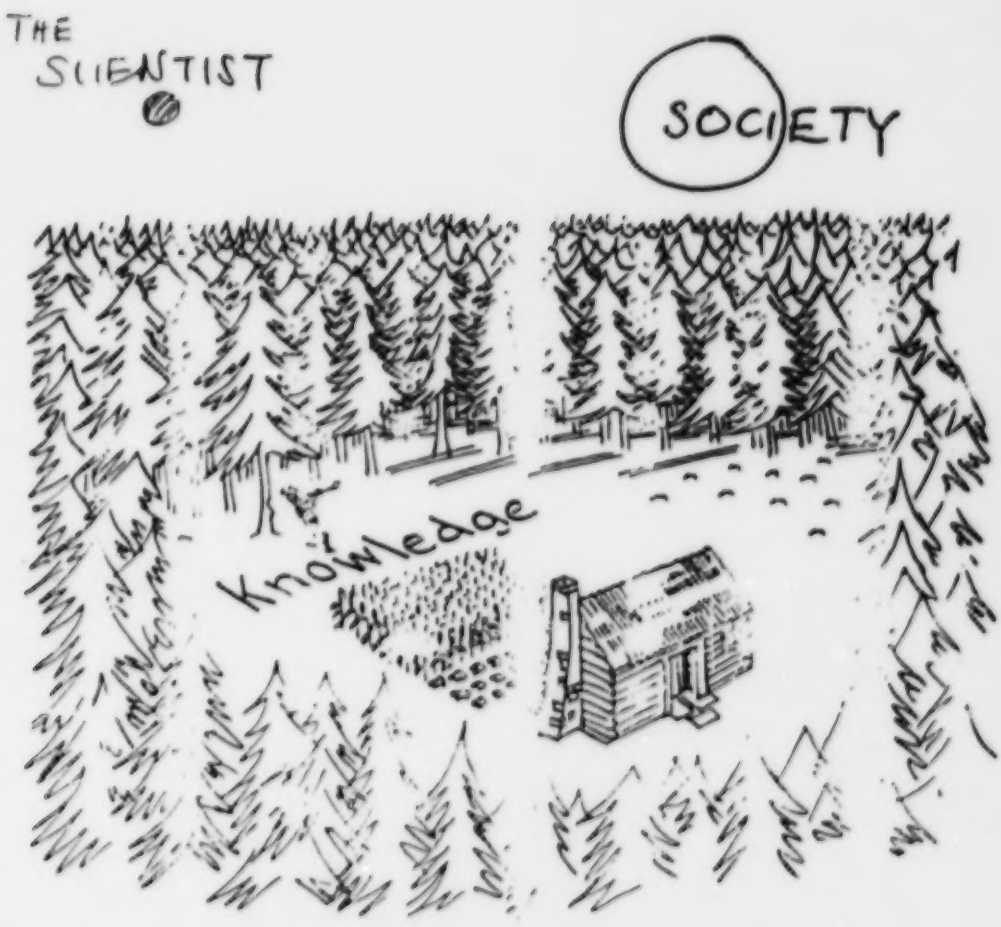
The third part will exemplify how classroom resources can not only teach «good» science well, but also show those STS features which begin to deliver an understanding of the nature of science, of the social purpose of technology, and of citizen participation. Science Technology and Society education is education through science as well as in science.

Part I

Our first need, when thinking about Science Technology and Society education is to clarify ideas about the link between science and the society. For this I shall rely heavily upon a book *Teaching and learning about Science and Society* by John Ziman (1980). In this he draws attention to a number of different models of science. For our purposes just three of these may be enough.

The first perspective sees science as an activity which is the individual's lone struggle to produce knowledge. It denies any serious link with society's aims or beliefs. Most of those who hold this asocial view also see the construction of knowledge as both individualistic and unproblemmatic. Experiments, in this perspective, are decided by the «verdict of Nature», which is quite unaffected by the requirements or beliefs of human society.

Illustration 1



from "Teaching and Learning about Science and Society"
J. Zimane (1980) WP.

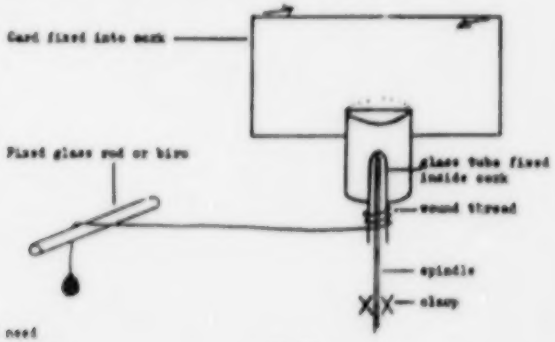
The second model shows the «instrumental» view of science in which most governments and heads of industrial firms believe so strongly in the present age. It cherishes science quite simply as an instrument of national purpose and wealth. Whether the desired outcome is military or civil, the «black box of science» is there to deliver the goods. Not least of the reasons why science is a black box in this model is the absence of public understanding of science it promotes. An instrument of wealth is there to be managed, not to be discussed by ordinary members of the public!

Illustration 2

ENERGY PROJECT

'Up-hill' ENERGY of a RAISED WEIGHT is called
POTENTIAL ENERGY
It can be used to do work for us.

AN AIR-FAN
This works by the POTENTIAL ENERGY of a raised weight.



You will need

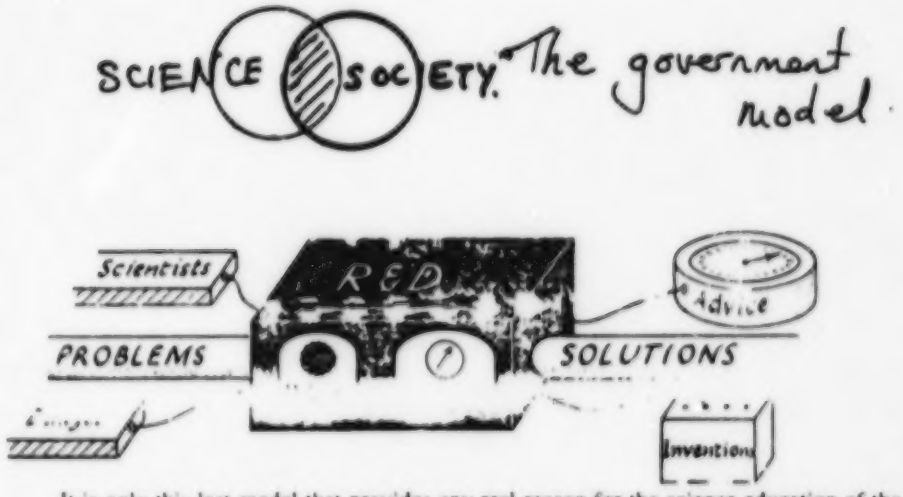
- a cork
- a glass tube
- a spindle
- a knife
- a piece of card
- thread
- a weight
- a glass rod or wire
- a clamp stand
- scissors

1. Make your fan.
2. Let the weight fall 50cm. Time it.
3. Make the card smaller by cutting ten strips off each end.
4. Repeat number 2

P.T.O.

Ziman's last model shows the black box made transparent. Now the scientific community which constructs the knowledge and the apparatus they use are shown. So also are the two-way links between science and the society.

Illustration 3



It is only this last model that provides any real reason for the science education of the majority of our children. If science were no more than an instrument of government we should not need to teach its interactions with society more than we would want to teach advanced economic theory. Few of our pupils need to be educated for a future as high-ranking government ministers. But if science affects *everyone's quality of life*, then everyone has a right to understand and even question its applications. That would mean that we do need a new approach to science education.

Part II

If we are to recommend this new approach to science education it is important to begin by considering the broad rationale that any country might have for the education of its future citizens. What will be argued in this section is loosely based upon the writings of Malcolm Skilbeck (1984). He has suggested that there are three quite separate reasons for educating the next generation. These apply equally to any subject in the school curriculum. It seems to me, however, that they are particularly appropriate for science education at the present time.

Science for cultural transmission

This is the oldest reason for teaching science. It simply asserts that we need to pass on to our young people the knowledge that we ourselves have inherited. It was Isaac Newton who is supposed to have sait that:

> «...if I have seen further than other men it is because I have stood upon the shoulders of giants.»

Historical scholars have debated who first used this metaphor and have traced it back to at least two centuries earlier. Over and above this academic argument lies the obligation to teach each generation our present body of accepted science so that they may see further than we have been able to do.

Modern history and philosophy of science have placed great emphasis upon the role of consensus in constructing science. Some, like Tomas Kuhn, have argued that it is precisely the possession of a shared perspective that makes possible scientific work, and the communication of its results between scientists. It follows from this that if we do not teach our children and young people at least a modicum of the accepted views of science we effectively prevent them from entering or participating in the world of science.

But we must teach our students skilfully and with care. There is little point in pressing too many facts into their heads if they have no way to retain and understand this knowledge. The work of many researchers has shown that, at the end of the schooling process, students may retain the same ideas as they had at the beginning. The illustration below is taken from the work of Mary Simpson on the teaching of photosynthesis to Scottish children. The point it makes so clearly could just as easily be made of many other topics in the school science curriculum. (Illustration 4).

Illustration 4
Pressing ideas into the heads of Children

In our science teaching we shall also have to choose the words we use with great care. By listening to children we can hear that their use of words is not the same as that of university scientists. The chart below shows how the use of the simple word «animal» changes with age over the time that pupils attend elementary school. (This data was collected by practising teachers in New Zealand). There is little point in teaching about the characteristics of the animal kingdom if the very words we use are so differently understood by children.

(Data - «Is it an animal?»)

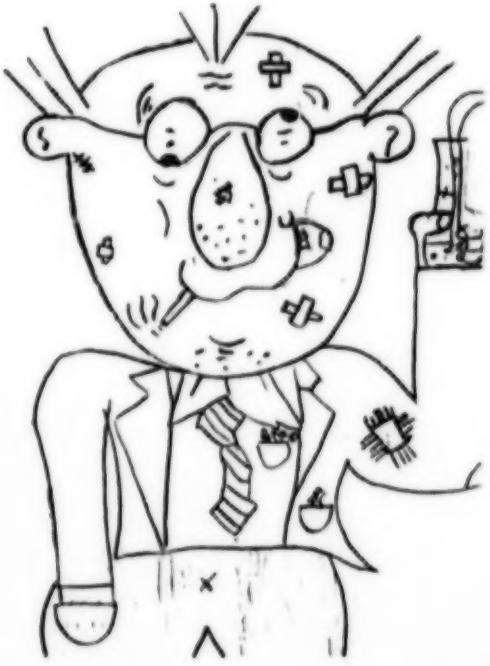
This sort of evidence could, no doubt, be replicated by your own work in CIRADE.

Science for vocational study

This reason seems self evident. The argument for education based on vocational skills makes commercial good sense, especially when each country has to strive so hard for industrial success and national wealth. So many jobs are now rooted in science and technology that we need quite routinely to introduce our children to its thinking and its techniques. There is a good argument here for allowing plenty of practical experience and experiment in our school science, which should include computer work and electronics. Adult employment in the future will almost certainly build upon such skills.

There is also an argument for teaching children what kind of work our scientists and technologists do. Too many children, like the one who draw the illustration below, seem to know nothing about what scientists do except what the comics tell them. Other children get so firm an impression that scientists are always very clever people that they become sure, even when quite young, that they would never be able to understand science or use it in their place of work. *(Illustration 5)*

Illustration 5
«Picture of a Scientist»



But we must also add a very serious proviso about this vocational argument. True education must be broad in every sense - contents and presentation. We need a vocational element in our school science education - but not at the expense of that «opening of windows on the world» which is the characteristic of all true education.

Science for societal re-construction

Every generation re-constructs their own society. In some epochs, like our own, this may be a radical and turbulent process. In others little may seem to happen beyond the gentle trimming of regulations and manners to suit new moods or needs. In either period, however, the citizenry will need to understand the issues and problems that face their society and attempt to steer a course which will be wise and just. This sets a new and ambitious requirement for all education and is especially challenging for science.

This is an age of public and visible science: very many of the issues on which our society has to decide are science-based. We need only think of global environmental issues, of new medical technologies, or of Third and First World development, to see that science education could be, and indeed must be, a vital ingredient in our children's thinking about such matters.

These educational objectives are not particularly uncomfortable and challenging for any adult used to answering their own children's questions. It is true that the issues are sometimes very emotive, but they are already in the public arena, and none of our children can be ignorant of them. To refuse to allow our students a chance to discuss them in the context of the appropriate science lesson would disadvantage them shamelessly. The issues will certainly bring in moral and ethical values. The serious question we have to answer is whether this makes science education more or less important.

Part III

Perhaps this integration of the academic and the moral in education may still seem a bold and difficult step to some teachers. They could claim, with some justice, that high-flown rhetoric about «the purposes of education» and «the nature of science» are far too vague to offer any professional guidance. The third part of this talk will offer two simple examples of STS teaching in the classroom which are designed to show our pupils that science is about people, that science is fun, and yet also teaches them «good» science.

Using technology

The middle of STS, the «T» for technology, is often lost (Layton 1988). Others tend to argue that what is intended is only «non-technology». By this they mean that it is not, or even should not be, a matter of pupils designing and making, but only of discussing the benefits and risks of industrial innovation. That is the prevalent view in the USA, but not in Britain. Most advocates of STS in Britain want real technological work. The most basic characteristic of all technology is that it is designed to serve people - society.

Making a water turbine

Pupils of secondary school age already have some idea that there is public controversy about nuclear power and about the emissions from coal-fired power stations. Controversial topics are always welcome in the classroom just because the pupils already know that such topics are thought to be interesting and important by people outside the closed world of the school.

Many of the children will also know that there are other energy technologies which rely on neither fuels nor nuclear power, like solar power or hydroelectric power. These energy sources seem benign, «natural», and non-threatening. What most people know little about, and need to know much more if they are to think and speak usefully about the subject, is how such energy is «harnessed» and how efficiently we can use it. That is what the following exercise is all about.

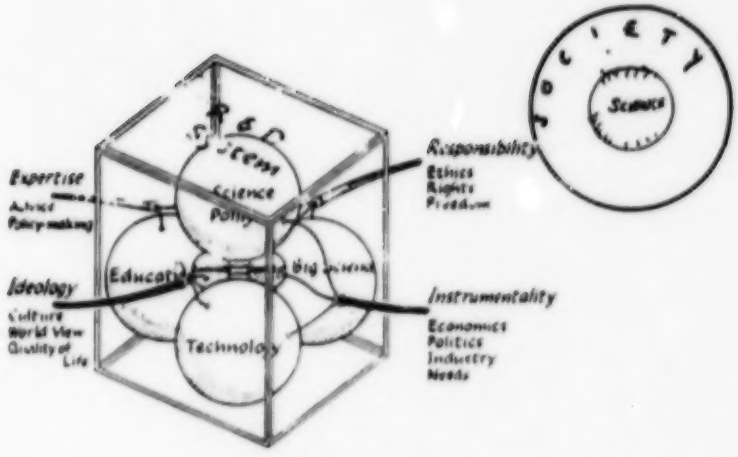
Making a water turbine and measuring its efficiency

The pupils first think about how water-power has been used in the past for grinding corn, and how it is used in hydroelectric stations today, in order to give civic importance to their work. A few swift questions are usually enough to re-awaken some knowledge of the social context of water-power. The children will also probably know that it seems to cause no pollution, and think of it as «good» technology.

They are then challenged to make a water turbine out of a cork, spindle, pieces of plastic (from yoghurt cups!) which they can shape, and sleeves into which the completed rotor can be fitted so that it turns. They will also need thread and some small weights.

The turbine is powered by a flow of water supplied by the pupils raising and pouring a measured amount of water (their energy, stored in raised water) on to the blades of the rotor. The task of the turbine is to raise a weight.

Illustration 6



So far this is a technological task. Like most technology it starts with people's needs (power), and people's values (concern about pollution).

The next stage is to improve the design - lengthening or broadening the blades of the rotor so that it turns faster or more powerfully for the same quantity of water flow. Later this will be translated into terms of energy. (With a little help the pupils can find out that «faster» and more «powerfully», are different and often competing conditions.)

Lastly the pupils need to conceptualise the notions of energy and energy efficiency, which may have already started to form as they struggled to make a «better» turbine than their neighbours. For this the pupils may be able to build on previous work. They will measure how much energy they have transferred to the turbine (weight of water X the distance they have raised it). Then they measure how much useful work the turbine performs in terms of raising the small weight dangling on the end of the thread. The result is rarely more than 7% or 8%.

There is no need to continue further with details of the exercise. As most teachers could tell, either from their own experience or from the instructions above, this project is fun. Water tends to spray around from some designs which spin too fast, or have very long blades. Carrying it out also has an element of competition.

Either of the following make a much more enjoyable ending to this energy exercise than does an extended lecture on the social uses of energy:

a) *pupils' strip cartoon* of how energy moves through the atmospheric machine which is powered by the sun's incoming heat energy, and is tapped for our use,
or
b) *stories and pictures for pupils* to show the risks or hazards of water power - the dreaded «mill-race» of earlier times where the spent energy of the water could drown anyone who fell in - or photographs to show the environmental impact of a new hydroelectric dam.

Water-power technology means, as technology always does, that people, like our students, have to make choices between energy, the environment, and human risk.

Example II Local technology and local culture

One of the objectives of STS is to show science and technology in different cultural contexts. This is to point up the social nature of technology (as well as the imaginative function of scientific thought). In the following example it is the first of these that is paramount.

The sub-Saharan countries have been growing more arid over the last centuries. The old solution to this problem was to build lines of stones to hold the water. Now it becomes essential that these lines follow the contours very exactly otherwise the flash flooding will be channelled by the stones and swirl along the walls taking even more soil with it. Scientists from one of the famine relief organizations have been consulting with farmers, and together they came up with a simple manometer made from plastic hose attached to two measuring sticks. With this they can now mark out level lines on this nearly flat landscape for laying down the stones far more exactly. This simple aid to existing practices can increase crops by at least as much as 35-40%.

> It is suggested (*see Exploring the Nature of Science* Solomon 1991 p15-18) that pupils learn about air pressure and water pressure in the usual way, as African children will also learn it. Then they make a model of the manometer and use it to mark out the contours on some uneven piece of land. I can vouch for the fact that this requires group collaboration of a high order. A dropped stick at one end involves spilled water and may mean going back to refill the tubing, and even starting all over again.
>
> Alternatively the groups of pupils may begin by reading pieces of text and draw pictures to illustrate their understanding of the information. What they produce inevitably bears little resemblance to the actual landscape or plant-life of Burkino Faso but it does help them to conceptualise the problem.

The most valuable outcome of a cross-cultural study in an STS context is not a detailed understanding of some technological development in another country. It is a more general understanding that every locality has difficult issues and that each community tries to cope with them using both scientific and local knowledge about the environment, technological inventiveness, and concern for how people live.

In Britain country children will know about the controversies over hedges, and town children about threats to parks from diseases spread by dog excrement. In Montreal I would expect the issues to be different again.

One succesful method of studying such issues is to use local newspapers. This has the advantage of a familiar setting so that our pupils are in a better position to understand the concerns of people. The disadvantage is that it is not possible to plan for some appropriate local crisis just as that point in the syllabus is reached! There are two alternative strategies for dealing with this. One teacher may arrange to collect newspaper cuttings on problems affecting the soil in local sites over a few months and then use them at an appropriate point in her scheme of work. Others may make an opening for this kind of exercise when the news breaks - it may be pollution of the water supply, trying to make a graffiti-free surface for bus-shelters, or looking after the elderly in some different way.

> The pupils cut out newspaper articles and record radio interviews wherever possible. These are brought to school and the class activity is to mount them, together with connecting passages which groups of pupils are asked to contribute. To do this the pupils are encouraged to talk in their groups while planning and writing so that they can exchange information and begin a discussion of what THEY think should be done. At the end there is a class display and also a plenary discussion with the teacher in which she draws out the reactions of the children and shows that she values their contributions.

Conclusions

The kinds of themes that STS education might address include the following:

- environmental threats, including global ones, to the quality of living,
- the economic and industrial aspects of technology,
- the fallible nature of scientific explanation,
- personal values and group concerns about the uses of technology, leading to democratic action,
- the multicultural dimensions of technology.

Not all these have been covered by the two examples listed above, nor would it be appropriate to give further examples here. However there are two points concerning choice of any teaching materials which I should stress.

In the first place, although the two examples above served to illustrate some teaching strategies, they are not set us as formal recipes to be copied. It is the teacher who should make the professional decision of *how to teach*, not a visiting lecturer. *What to teach* is a choice which only the local community is in a position to make. In Oxford UK, and in Montreal Canada, the choices are bound to differ.

Secondly I want to emphasise that STS does not aim to be an alternative to science teaching nor even to make an addition to it. Studies in the public understanding of science (Solomon 1990) show that the remnants of a traditional science education do little to empower the citizen to reflect on the important science-based issues of the time - unless science itself is presented in this social context. STS claims that, through its motivation of students and its relevance to the way in which we all live, it simply is the appropriate science teaching and learning for the present age.

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Centre Interdisciplinaire de Recherche sur
l'Apprentissage et le Développement en Education
Université du Québec à Montréal
C.P. 8888, Succ. A,
Montréal, Québec
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Publié par le Centre Interdisciplinaire de Recherche
sur l'Apprentissage et le Développement en Education
Université du Québec à Montréal
Conception graphique: Pierrette Prévost